E7.3-11036
CR-133882

ERT Doc. P-412-4

STUDY TO DEVELOP IMPROVED SPACECRAFT SNOW SURVEY METHODS USING SKYLAB/EREP DATA

(EREP Investigation No. 420)

James C. Barnes, Principal Investigator
Environmental Research & Technology, Inc.
Lexington, Massachusetts 02173

Second Quarterly Progress Report
Covering the Period 14 June to 15 September 1973

Contract No. NAS 9-13305

Prepared for:

Principal Investigations Management Office
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
Houston, Texas 77058

Technical Monitor: Timothy T. White
Code TF6

PURPOSE OF INVESTIGATION

The purpose of this investigation is to compare and evaluate Skylab data for mapping of snow cover. Visual interpretation of the S190 photographs will be performed to map areas that are snow-covered. The S192 imagery and digital printouts, S193 data, and S194 data will then be compared to the S190 photographs to determine how much additional information on areal extent of snow can be obtained from various spectral bands, thermal data, and microwave data. Snow-depth and area measurements taken routinely by various Government agencies in the Sierra Nevada, Cascades, and Great Plains shall provide ground truth. The relatively high-resolution EREP data will be compared with television and radiometric measurements from other satellites, and available aircraft imagery, to determine the optimum future system for mapping the areal extent of snow. The results of this investigation will enable a more accurate assessment of the extent of snow cover in the United States and aid in prediction of run-off and better management of the country's water resources.

ACCOMPLISHMENTS DURING REPORTING PERIOD

During this reporting period the initial EREP data sample from the SL-2 mission has been received. The data are for two test sites: Site 318107-Sierra Nevada in California (EREP Pass 3, 3 June); and Site 318108-Cascades in Washington and Oregon (EREP Pass 8, 11 June). In addition, EREP data for use in a separate investigation being conducted at ERT (EPN 439; D. Chang, Principal Investigator) have also been received. These data, collected on EREP Pass 5 on 5 June, cover mountainous terrain in Utah, and, therefore, have application to the snow-mapping experiment.

The data now on hand at ERT includes S190A 70mm film (positive and negative), S191 16mm DAC film, and S192 screening film. The appropriate tabulations for each sensor for the respective passes have also been received. It is understood that no S190B photography was taken for either the 318107 or 318108 test sites; S190B photography was taken, however, for the Utah area on the 5 June EREP pass.

S190A Film

The S190A film for Pass 3 covers an area extending southeastward from Lake Tahoe across Mono Lake to about Las Vegas. Snow can be identified in the Sierra Nevada to the south of Lake Tahoe and to the west of Mono Lake. In the area near Lake Tahoe, however, considerable cumuliform cloudiness exists obscuring some of the snow. To the east of the Sierras, snow can also be identified in the White Mountains; although some clouds also exist in that area, the mountains are less obscured than are the Sierras.

The EREP Pass 8 data-take extends from the Washington-Oregon border near Portland southeastward across eastern Oregon. A large part of this swath is cloud obscured, especially in the eastern part. Near the western end of the swath, Mount Adams and Mount St. Helens in Washington and Mt. Hood in Oregon can be identified in spite of the clouds. The reflectance of these snow-covered peaks is considerably higher than that of the thin clouds covering the region.

In the S190A (and S190B) film from EREP Pass 5, the snow-covered Wasatch Range southeast of the Great Salt Lake is particularly distinct. At the time of the data-take the region was completely cloud-free.

The S190A film has been examined to determine the exact areas covered on each of the passes. For selected frames, enlarged prints are being made from the 70mm negatives. From these prints, the snow cover is being mapped using the techniques developed previously to distinguish between snow and cloud and to locate the snow line (see, for example, Barnes, J., and C. Bowley: "Use of ERTS Data For Mapping Snow Cover in the Western United States", Proceedings of Symposium on Significant Results of ERTS-1, March 5-9, 1973, NASA/GSFC). Using these prints and the 70mm positive film, the six S190A camera stations are being examined to determine the differences in the appearance of snow in the various spectral bands.

S191 16mm Film

The S191 16mm DAC film for Test Site 318107 has been reviewed. Because of the blurred image on the film, no identifiable features are visible. The film is, therefore, not useable for locating the geographical coordinates of the S191 data.

S192 Screening Film

The S192 screening film has been examined, and the specific intervals for which data are required have been selected. The data request has been submitted to the PIMO. For Site 318107, the part of the Sierras with the least cloud obscuration in the S190A photography is not covered by the S192 because of the narrower swath scanned by the sensor. The White Mountains, however, can be identified in the screening film. For Site 318108, the snow covered mountains are difficult to identify in the screening film because of the cloud obscuration. Nevertheless, data for a small interval covering the area where the mountains are visible in the S190A film have been requested; these data may be useful for determining which spectral bands are the most useful for cloud penetration.

Data have also been requested for the segment of EREP Pass 5 covering the Wasatch Range in Utah. Because of the cloud-free conditions, the Wasatch Range is distinct in the screening film. Moreover, a dramatic reversal in the reflectance of the snow is observed between the visible and near IR channels. In Channel 2 (0.46 - 0.51 μm) the snow has a high reflectance; in Channel 11 (1.55 - 1.75 μm), however, the snow appears almost black, having a much lower reflectance than the surrounding terrain.

The sharp drop in the snow reflectance in the near-IR is believed to be due to the existence of a layer of melt-water on the snow surface. Maximum temperatures at Salt Lake City were about 70°F on 5 June and on the preceding days. It is probable, therefore, that the snowcover in the Wasatch Range (highest elevation-about 11,000 ft.) was in a melting state at the time of the EREP pass. The decrease in the reflectance of melting snow and ice in the near IR has been reported by investigators using ERTS data (Barnes and Bowley, paper referenced above; McClain, E.P.: "Detection of Ice Conditions in the Queen Elizabeth Islands", Proceedings of ERTS-1 Symposium, September 29, 1972, NASA/GSFC).

However, because the near-IR band of the ERTS-1 MSS extends only to 1.1 μm, the effect is much less dramatic than in the S192 screening film. The S192 data will provide the first opportunity to study quantitatively the snow reflectance in the near-IR spectral region. The difference in reflectance between the visible and near IR can then be used to determine areas of melting snow. Information on the state of the snow surface (i.e., whether the snow is dry or is melting) is of vital interest in snow hydrology.

S192 Test Tapes

Two S192 test tapes have been received. The tapes have been tested and appear to be compatible with the ERT computer system.

Significant Results

A separate discussion of significant results and their relationship to practical applications or operational problems is given at the end of this report.

TRAVEL SUMMARY

Mr. James Barnes, the Principal Investigator, visited Johnson Space Center on 13 - 15 September. The purpose of the visit was to participate in the SL-4 crew lecture program on Skylab visual observations of the earth. During the visit Mr. Barnes met with the Contract Technical Monitor to discuss the status of the EREP sensors, the schedule for processing of the SL-2 electronic data, and the progress of the investigation to date.

PLANS FOR THE NEXT REPORTING PERIOD

It is understood that the SL-2 electronic data, except for the S193 RADSCAT measurements, will be mailed from JSC within the next few weeks. When the computer tapes are received at ERT they will be processed, and the resulting data will be analyzed as specified in the Statement of Work of the subject contract. For the S192, the accompanying imagery will be analyzed first, and then the tapes will be processed for the areas and channels with useable data.

During the next reporting period, mission support will be provided for the SL-4 mission. The scheduled launch date and duration of the final Skylab mission are such that acceptable snow cover conditions should prevail in all five test sites during the mission.

SUMMARY OUTLOOK

The EREP data collected on the SL-2 mission are sufficient to undertake the initial analysis as specified in the Work Statement of the subject contract. If the SL-4 mission is carried out as planned, it is believed that the objectives of the study can be successfully met.

FINANCIAL REPORT

In accordance with Appendix A of the Work Statement of the subject contract, the Financial Management Report is being submitted as a separate document.

Title: SURVEY TO DEVELOP IMPROVED SPACECRAFT SNOW SURVEY METHODS USING SKYLAB/EREP DATA

(EREP Investigation No. 420)

Principal Investigator: James C. Barnes
Environmental Research & Technology
Lexington, Massachusetts 02173

DISCUSSION OF SIGNIFICANT RESULTS

The initial analysis of EREP data from the SL-2 mission has been undertaken. Snow distributions are being mapped from the S190A photography for three mountain areas: the Sierra Nevada near Lake Tahoe and Mono Lake; the Cascades near the Washington-Oregon border; and the Wasatch Range in Utah. A part of the snow cover in the Sierras is cloud obscured; in the Cascades, however, the snow-covered peaks of Mt. Adams, Mt. St. Helens, and Mt. Hood can be identified through thin clouds because of their high reflectance. The Wasatch Range was cloud-free at the time of the EREP pass.

In the S192 screening film, a dramatic reversal in the reflectance of the snow in the Wasatch Range is observed between the visible and near-IR channels. In Channel 2 (0.46 - 0.51 μm) the snow has a high reflectance, whereas in Channel 11 (1.55 - 1.75 μm) the snow appears almost black, having a much lower reflectance than the surrounding terrain. The sharp drop in the reflectance in the near-IR channel is believed to be due to the existance of melt water on the snow surface. Although investigators have reported this effect previously using ERTS imagery, the S192 data provides the first opportunity to study quantitatively the snow reflectance in several visible and near-IR channels. The results will have direct application for developing a technique to determine the condition of the snow surface (i.e., dry or melting), a significant parameter in snow hydrology.